

THE  
CEMENT-MATERIALS  
OF  
SOUTHWEST ARKANSAS.

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## The Cement-Materials of Southwest Arkansas.

BY JOHN C. BRANNER, STANFORD UNIVERSITY, CALIFORNIA.

(Chicago Meeting, February, 1897.)

INQUIRIES are frequently made concerning the chalk- and clay-beds of Arkansas, usually with a view to the manufacture of Portland cement. The chalk-deposits were first described by Professor R. T. Hill in the annual report of the *Geological Survey of Arkansas for 1888*, vol. ii., pp. 153-162. Since the publication of that report I have visited localities then unknown, and have accumulated considerable additional information concerning these deposits, all of which is brought together in the present paper. My report upon the clays of the State has never been published; only a few of the more conveniently available deposits are mentioned in the present paper.

### THE CHALK-DEPOSITS.

*Stratigraphic Position of the Chalk.*—The chalk-deposits of Arkansas belong to rocks of Cretaceous age. The Cretaceous rocks are confined to a single definite area in Southwest Arkansas. Beginning on the Ouachita river, a little northeast of Arkadelphia, its northern or upper margin follows a line about five miles southeast of, and approximately parallel to, the St. Louis, Iron Mountain and Southern Railway from Arkadelphia to the river-bottoms near the mouth of Bois d'Arc creek on Red river, about ten miles southeast of Fulton, and thence westward to a point between Texarkana and Red river.\* The lower and northern border runs westward from the same point on the Ouachita river past Hollywood, Clear Spring, Brocktown, Murfreesboro and Atwood to Ultima Thule.

The chalks are not found throughout these Cretaceous rocks, but are, so far as is now known, confined to the Upper Creta-

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\* This approximate location of the upper limit of the Cretaceous is made upon the authority of Professor Gilbert D. Harris, of Cornell University. See his report upon the "Tertiary of Arkansas," pp. 18-20, and map.

ceous. Professor Robert T. Hill, who has made a special study of the Arkansas Cretaceous, divides it into Upper, Middle and Lower Cretaceous, and places all the chalk-beds in the upper division.\*

The divisions made by Prof. Hill are based upon palæontologic evidence, which, for present purposes, is of local importance only; for, according to his correlations, the several chalk-deposits do not belong to the same subdivisions of the Upper Cretaceous. If Prof. Hill's subdivisions hold over a considerable area, the chalk-deposits are simply local variations of different beds.

In the main, however, the points at which chalk occurs lie in a belt which is on the general line of strike of the Cretaceous rocks of the State, as will be seen by referring to the accompanying map, Fig. 1.

The entire series of Cretaceous rocks was deposited in a sea, the northern border of which was originally somewhere north of the present northern border of the Cretaceous, probably at or near the base of the Ouachita mountains. They were laid down upon the upturned edges of the rocks of the Lower Coal-Measures. At the close of the Cretaceous the country to the north was elevated, the sea withdrew southward, and erosion began to remove the soft Cretaceous sediments. This erosion carried away all the northern margin of these beds, uncovering the palæozoic rocks on which they were laid down, and carving the land-surface pretty much as we now find it.

The Cretaceous rocks were in places so deeply decomposed that the soil thus formed conceals the nature of the underlying beds. In other places beds of sediments were deposited on top of the Cretaceous ones. Some of these beds were thin, and when they were afterwards cut through by erosion the underlying rocks were again exposed; but in most instances they were so thick as to completely hide the rocks beneath. All these Mesozoic beds have a gentle southeast dip away from their old shore-line, so that those beds which crop out along the watershed north of Washington, at Columbus and Saratoga, are at a great depth below the surface at Hope and Fulton. The streams have in many places cut their way down through some

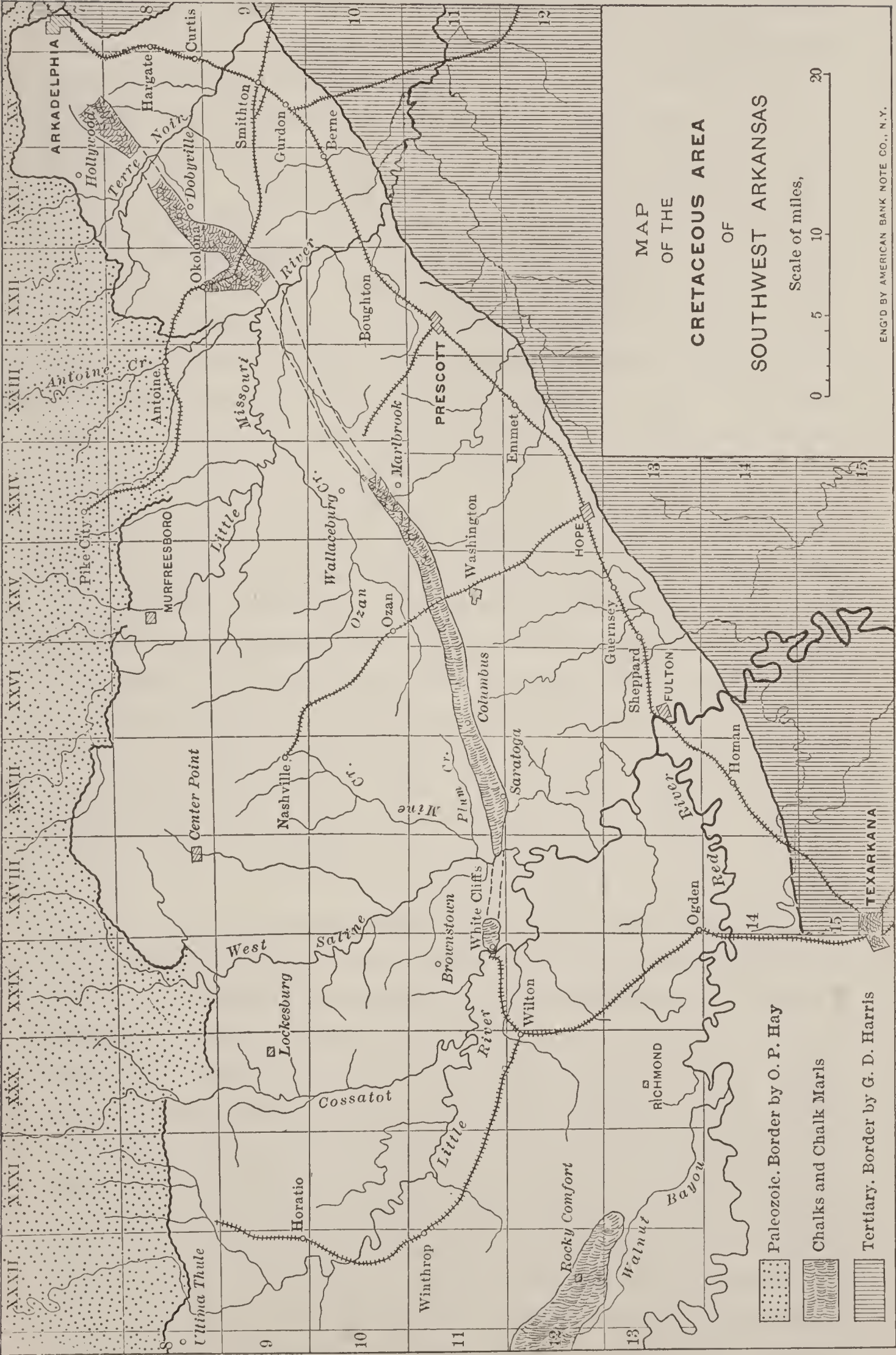
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\* *Ann. Rep. Geol. Surv. of Ark.* for 1882, vol. ii.; "The Neozoic Geology of Southwestern Arkansas," by Robert T. Hill, Little Rock, 1888, p. 188.





FIG. 1.



ENG'D BY AMERICAN BANK NOTE CO., N.Y.

of the Cretaceous rocks, and in their meanderings have produced wide valleys. The remnants of these beds may be seen occasionally in the tops of some of the hills.

The chalk-bed at White Cliffs has been cut through entirely, so that it now stands 130 feet or more above water on Little river. On the Saline river, however, six miles due east, the same chalk-beds are at the level of that stream.

It should be distinctly understood that chalk occurs in Arkansas only within the Cretaceous area above specified. One may occasionally hear of "chalk-rocks" or "cotton-rocks" in other parts of the State, but in no case are they true chalks. In the region north of the Boston mountains some of the magnesian limestones, sometimes called "cotton-rocks," have been taken for chalks. In the same region a siliceous limestone often forms, upon partial decomposition, a spongy, soft, white rock that is occasionally taken for chalk. It is, however, almost pure silica instead of almost pure limestone. Again, within the Cretaceous area southeast of Murfreesboro, in Pike county, there are considerable beds of white, soft kaolin that has been used in the schools as lump-chalk upon blackboards. In that neighborhood this kaolin is commonly known as chalk. At the northern end of Crowley's ridge, in the northeast corner of Greene county, is a place known as Chalk Bluffs, on account of a white clay exposed at the base of the ridge at this place. Instead of chalk, the material is white pottery-clay, as is shown by the analyses given of it in Owen's first report (p. 21). It contains less than 1 per cent. of lime.

*Appearance.*—The chalk of Southwest Arkansas has been known hitherto as "rotten limestone." This popular name conveys a general idea of its appearance. Wherever it is uncovered it is soft and earthy in texture, is easily cut with a knife or scratched with the nail, and breaks up in conchoidal fragments when freshly exposed. It is cream-colored to white when dry, or has a grayish cast when damp, and especially when uncovered below the surface of the ground. A microscopic examination of the chalk shows it to be composed principally of the calcareous skeletons of foramenifera. Like most limestones, the chalk forms a rich soil upon decay, and the admixture of organic matter makes this soil very black and sticky. The famous "black lands" and "black waxy lands"



of Southwest Arkansas are, indeed, due to the decay of the lime-bearing beds of the Cretaceous area. In some places these soils are in place, resting upon the rocks from which they are made; in other places they have been carried down by water to lower levels and spread out over the "bottoms."

*Composition.*—According to the books, chalk is "a soft white rock, consisting almost entirely of carbonate of lime in a pulverulent or slightly consolidated state, and readily soiling the fingers when handled." The lime-rocks of the Cretaceous are not all chalks. Many of them are too hard to be classed as such, and, though their composition would not exclude them from available material, their hardness is against them. The softer the rock the more easily crushed, and hence the cheaper.

All the analyses made of the chalks and of the associated rocks are brought together in Table I., accompanying this paper.

Attention should be directed to the fact that these analyses are not all of what are considered good chalks. They were made with a view to determining the nature and availability of the various beds, and they are all given as of some possible value in the efforts of practical cement-makers to settle upon the best rock and to avoid undesirable ones. It will be seen that many of the samples show chalks high in lime and low in deleterious ingredients. The highest percentage of magnesia found was 3.02 per cent.; the average is below 2 per cent.

#### *Notes on Leading Deposits.*

The following details will be useful to those who may have occasion to locate or use the Arkansas chalks. I shall begin with the westernmost exposures and follow them eastward as far as they are now known to me.

*Rocky Comfort.*—The chalk-beds about Rocky Comfort, Little River county, are among the best in the State. At that place they extend over the State-line into the Indian Territory, and eastward they are exposed here and there over the rolling timbered country to and including Section 6 in 13 south, 31 west, a distance of 10 miles. The chalk is not everywhere exposed along this belt, however, for most of the country is covered by gravels, sands and clays, from 3 to 6 feet thick, that conceal the Cretaceous beds. The nature of the concealed chalk-surface

is sometimes shown by the character of the well-waters through the region. Some of the waters are hard, as would be expected in a limestone country, but others are quite soft. The reason for this difference is shown by the section given in Fig. 2, which is sufficient explanation of the occurrence of two kinds of water near each other in wells of the same depth.

The hills about Rocky Comfort are capped by gravelly and sandy clayey soil, beneath which, and separating it from the chalk, is generally a bed of coarse pebbles. Three-quarters of a mile north of Rocky Comfort begins a "post-oak flat," the surface of which is a gray sandy clay, streaked with yellow, and containing a few small pebbles. This sandy clay overlaps the lower or northern edge of the entire chalk-area about

FIG. 2.

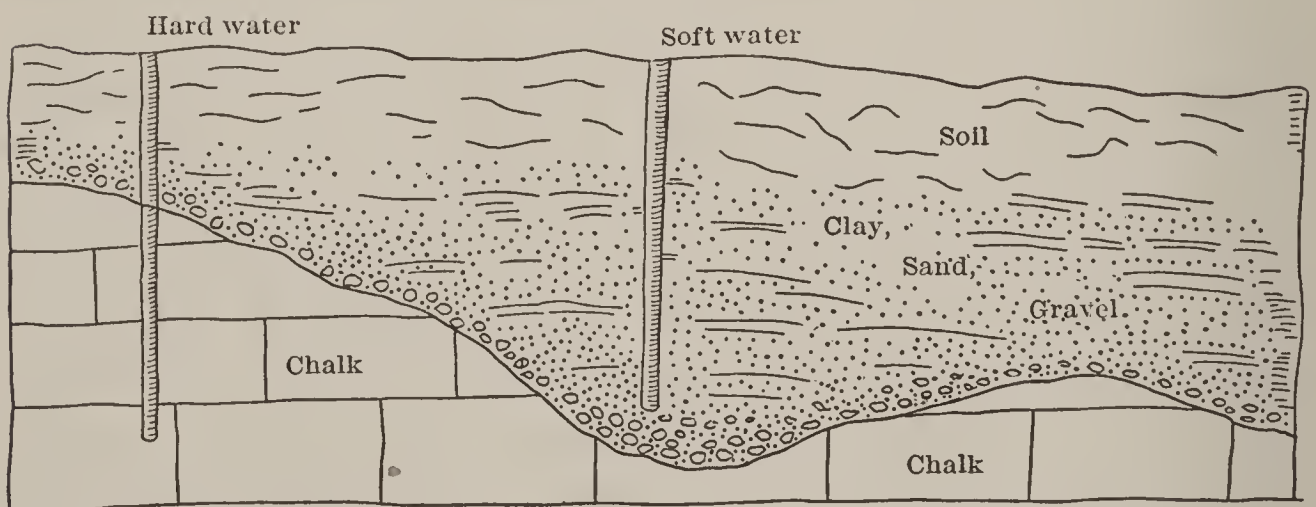


Diagram showing Wells of the Same Depth which Yield Different Kinds of Water.

Rocky Comfort. The chalk beneath these clays is dove-colored, but becomes cream-colored upon weathering. It is usually jointed, and the weathering begins along the joints. A well dug at the old brick-yard in 12 south, 32 west, Section 8, southwest quarter, passes through the clays and enters the chalk. Chalk was struck also north of Flat creek in Section 6 of the same township and range. Holman's well, in 12 south, 32 west, Section 18, southeast quarter, is 308 feet deep; 10 feet of shaly limestone overlies a blue chalk, which crumbles after long exposure. At 160 feet there are three 6-inch layers of reddish sand. Mr. J. H. Means, who examined the country about Mr. Holman's, thinks the shaly limestone at the top is decomposed chalk. In any case the chalk is more than 300 feet thick at this place, for the bottom was not reached.



A well in 13 south, 31 west, near the center of Section 6, struck the chalk after passing through 6 feet of clay. At Mr. Malden's, on the same section, the chalk was covered by 5 to 6 feet of earth. At a depth of 33 feet the chalk was of a bluish-gray color, and fell to pieces after exposure to the weather.

In 12 south, 33 west, Section 12, northwest quarter of the southwest quarter, a well dug on the low land struck the chalk at a depth of 8 feet.

In the southeast quarter of Section 11 of the same township and range the chalk is exposed in a bluff. In 13 south, 32 west, Section 1, northeast quarter, the chalk is covered by 8 feet of soil and clay. At the center of Section 3, 13 south, 32 west, a well 33 feet deep did not strike the chalk. Wells dug near the eastern boundary of the chalk-belt show that the chalk is covered by 8 to 10 feet of soil and clay, and that the rock is compact and bluish wherever it is penetrated.

At the residence of Col. A. D. Hawkins, east of Rocky Comfort (12 south, 32 west, Section 27), a well 57 feet deep is in chalk for almost the entire distance. A sample of this chalk was examined chemically with the results shown in Table I., Analysis No. 4.

The two samples, Nos. 2 and 3, Table I., were taken from a gully in the southern part of the town of Rocky Comfort; they were about 2 feet apart when in place, and the only difference apparent in them was that of color, No. 2 being cream-colored and No. 3 bluish-gray. The analysis suggests that this difference was partly due to water.

From a personal examination of the chalk-beds about Rocky Comfort, I came to the conclusion that there were about 800 acres of the best white-chalk land in that region that could be quarried with little or no stripping of the overlying clays.

*White Cliffs.*—At White Cliffs landing, on the left bank of Little river, is a notable exposure of chalk (see sketch, Fig. 3). This exposure is in Little River county, 11 south, 29 west, Sections 25 and 36. At this place Little river cuts close to its left bank and leaves exposed a bluff of limestone and chalk about 130 feet high. The chalk proper forms the uppermost bed in the section, and is here about 30 feet thick, with a maximum of 40 feet.



FIG. 3.



Chalk Bluffs at White Cliffs Landing.



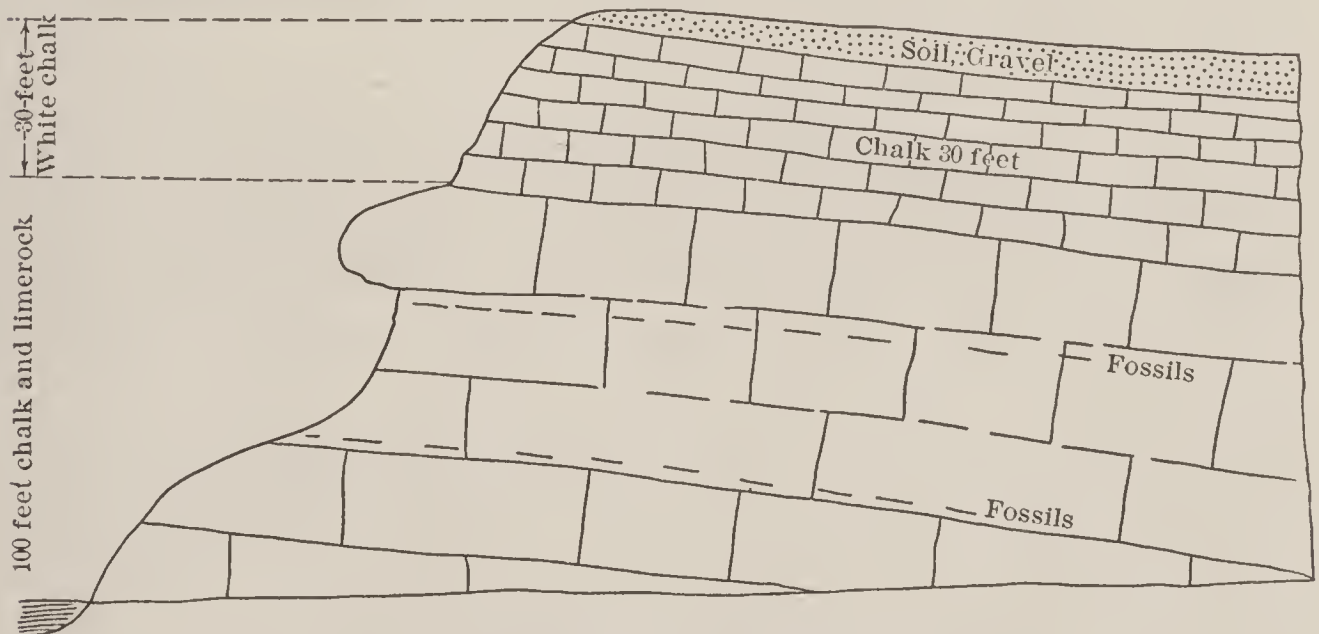
In 11 south, 29 west, Section 35, northeast quarter of the northeast quarter, is the section shown in Fig. 4.

The lower 100 feet contains a good many fossil oysters, and is not so pure as the 30 feet overlying it. In places the bed immediately beneath the chalk is sandy; this is shown at the base of the cliff at Kinsworthy's old lime-pit, a short distance north of the cliffs. Dr. N. F. Drake, who lately visited White Cliffs, records the following section of the beds beginning at the top of the cliff:

(1) 20 feet massive white chalk. This bed is probably 30 feet to 40 feet thick, but only 15 feet to 20 feet is exposed. This is the bed to be used for cement, etc.

(2) 10 feet of almost white pure chalk, with three bands of more arenaceous rock.

FIG. 4.



Section of Bluff at White Cliffs.

(3) 25 feet of rock, harder, whiter and less arenaceous than No. 4.

(4) 10 feet of rock, harder, whiter and less arenaceous than No. 5.

(5) 20 feet of light-gray arenaceous massive limestone or chalk. *Ostrea vesicularis*(?) common, especially abundant at the top.

(6) 30 feet to the river.

The rocks at White Cliffs landing dip southeast at a low angle, so that the bluffs adjoining the bottom-lands to the south cut off the chalk-exposure in that direction, while the general dip brings them to an end within a short distance northward. That they do not extend northward very far is also shown by the



well put down at Col. Coulter's house, about a mile and a half north and a little east of the White Cliffs landing. This well-section is as follows :

*Section of Well Bored at D. B. Coulter's, One and One-Half Miles North of White Cliffs.*

|                             | Feet. |
|-----------------------------|-------|
| Waterworn gravel, . . . . . | 3     |
| Clay, . . . . .             | 30    |
| Blue lime marl, . . . . .   | 200+  |
| White sand, water-bearing,  |       |

Analyses Nos. 13 to 18, inclusive, Table I., show the composition of the White Cliffs beds. Sample No. 14 was taken by Prof. R. T. Hill; the others were collected by myself with a view to getting average specimens, but the material was not systematically sampled.

The White Cliffs locality is six miles in a direct line from the main line of the Kansas City, Pittsburg and Gulf Railway, but a branch line has lately been built from Wilton to White Cliffs. This gives these deposits a considerable advantage they have never before had. Transportation by water is possible during much of the year, but the fact that it could not be depended upon the year round has always stood in the way of the working of the chawks at this place. With the railway in operation the whole year, and the river available a part of the year, the conditions are favorable for extensive development, if railway rates are not prohibitory.

The river-transportation will connect with other railways and markets at Fulton, Ark., at Shreveport, La., and at New Orleans.

*Saline Landing.*—Saline landing is six miles due east of White Cliffs. At the latter place the chalk is on the top of a bluff 100 feet above water, while at the former it is at the water's edge, and the country in the immediate vicinity is low and flat or rolling. I have no doubt, however, that the chalk at White Cliffs and that at Saline landing are the same bed. The south-east dip of the rocks at White Cliffs and erosion will readily account for the difference in elevation at the two points.

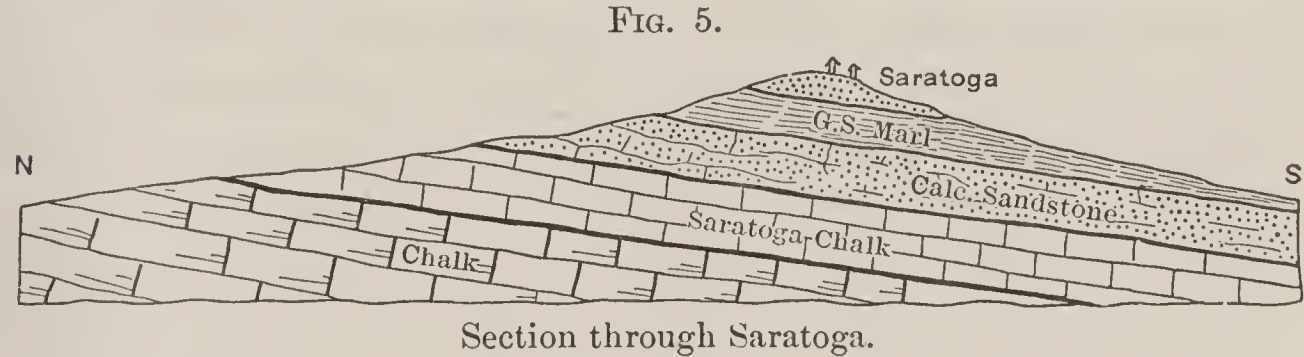
Fig. 5, a north-south section through Saratoga (11 south, 27 west, Section 33), shows the general geology of that region.

Saratoga is on a hill about 400 feet above the bottom and overlooking the surrounding country.

Saline landing is four miles west of Saratoga on West Saline river, and the chalk-beds shown in the section are exposed at the latter place and thence strike a little north of east, skirting the bottom-lands of Plum creek. East of this they are either concealed by soil or these particular beds thin out and do not appear again in the form of chalk.

At Saline landing the bottoms extend west of the river uninterrupted, so far as is known, to Little river. On the east bank of the stream there is a bank of chalk about 20 feet high exposed for a distance of 300 feet. These beds dip south at an angle of from three to four degrees.

This same chalk is exposed in the deep gullies just east of the stream.



Several years ago three wells were drilled just east of the stream on the farm of which the landing is a part.

The first of these wells passes through the following :

| <i>Record of Well Bored at Saline Landing.</i> |   |   |   |   |   |   |   |   |                   |
|------------------------------------------------|---|---|---|---|---|---|---|---|-------------------|
| Soil and clay,                                 | . | . | . | . | . | . | . | . | 25 feet.          |
| Brown sand,                                    | . | . | . | . | . | . | . | . | 1 foot.           |
| White chalk,                                   | . | . | . | . | . | . | . | . | 140 feet.         |
| Blue marl,                                     | . | . | . | . | . | . | . | . | 290 "             |
| Sandy bed with pyrites,                        | . | . | . | . | . | . | . | . | 10 inches.        |
| Sand in bottom of well.                        |   |   |   |   |   |   |   |   |                   |
|                                                |   |   |   |   |   |   |   |   | Depth = 457 feet. |

The following is the record of another well three-quarters of a mile northeast of the landing :

| <i>Record of Well Bored Three-quarters of a Mile Northeast of Saline Landing.</i> |   |   |   |   |   |   |   |   |                   |
|-----------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|-------------------|
| Soil,                                                                             | . | . | . | . | . | . | . | . | 1 foot.           |
| White chalk,                                                                      | . | . | . | . | . | . | . | . | 110 feet.         |
| Blue marl,                                                                        | . | . | . | . | . | . | . | . | 277 "             |
| Sandy bed with pyrites,                                                           | . | . | . | . | . | . | . | . | 10 inches.        |
| Sand in bottom.                                                                   |   |   |   |   |   |   |   |   |                   |
|                                                                                   |   |   |   |   |   |   |   |   | Depth = 388 feet. |



A thickness of 20 to 30 feet of the chalk is also exposed at this last place.

The first of these well-sections seems to show that the chalk bed is at least 140 feet thick. The second record gives a smaller thickness of the same bed because it is more eroded at that point which is away from the dip.

Analyses Nos. 10, 11 and 12 show the composition of the Saline landing chalk-beds.

Sample No. 12 was taken from a bed  $1\frac{1}{2}$  feet thick, exposed on the creek bank at the landing, that slacks or breaks up more rapidly than the rest of the deposit.

The chalk strikes east and a little north from Saline landing. For the most part it is concealed by the black soil formed by its decay.

It is exposed about  $1\frac{1}{2}$  miles northwest of Saratoga, where it forms gently rolling lands. The thickness here is from 30 to 50 feet, and it grades into the overlying marl-beds, which are 210 feet thick. The bottom of the chalk is not exposed at this place. From this point the chalk is exposed eastward to a point about two and one-half miles northwest of Columbus. The bed appears to be of even quality, but it seems to thin out towards the east. Two miles north of Columbus a gully exposes about 5 feet of the chalk. East of this point the chalk-bed of White Cliffs and Saline landing does not seem to be exposed.

*Outcrop of the Saratoga Chalk.*—The chalk-limestone beds east of Saratoga, west of Columbus, north of Washington and thence eastward to near Arkadelphia are above the upper White Cliffs chalk-bed. But inasmuch as the appearance and composition of these rocks seem to be such as to make them available at some places for the manufacture of Portland cement, their composition and their general distribution east of Saratoga are here given. The stratigraphic relations of these upper chalks to the lower ones will be seen by referring to the section given in Fig. 5 of the rocks at Saratoga. The White Cliffs beds are shown at the bottom of that section. These are followed above by a series of beds marked in the section as Saratoga chalk, calcareous sandstone, greensand marl and sandstone. The chalk is exposed just west of Saratoga. One mile west of Columbus these beds are 25 to 30 feet thick.

The section in Fig. 5 is not a detailed one. Dr. N. F. Drake gives me the following as the general sequence of the beds above the White Cliffs chalk from Saratoga eastward, as shown by his examination of the geology of the region in question:

- (1) Top of the hill at Saratoga; sands.
- (2) 100 to 200 feet of sandy black marl.
- (3) 20 to 40 feet of rotten limestone.
- (4) 10 to 50 feet bluish yellow marls.
- (5) 15 to 20 feet rotten limestone with *Ostrea vesicularis*.
- (6) 200 feet of yellowish marls with *Exogyra ponderosa* at the top.
- (7) White Cliffs and Saline landing chalk.

In 11 south, 27 west, Section 35, northeast quarter of the northeast quarter, on the farm of Thos. L. Jones, the rocks of the fossiliferous chalk are exposed. Samples sent from that tract by Mr. Jones were analyzed with the results given in Table I., Nos. 22 and 23. Mr. Jones says some of the rock is of a bluish color, but it bleaches on exposure and finally drops to pieces. The samples analyzed are from near the surface.

*Analyses of Fossiliferous Chalks from the Farm of Thos. L. Jones.*

|                                                        | I.           | II.          |
|--------------------------------------------------------|--------------|--------------|
|                                                        | Per cent.    | Per cent.    |
| Loss on ignition, CO <sub>2</sub> , etc., . . . . .    | 34.050       | 40.355       |
| Silica, SiO <sub>2</sub> , . . . . .                   | 16.617       | 5.002        |
| Iron oxide, Fe <sub>2</sub> O <sub>3</sub> , . . . . . | 1.512        | 1.218        |
| Alumina, Al <sub>2</sub> O <sub>3</sub> , . . . . .    | 5.343        | 2.785        |
| Lime, CaO, . . . . .                                   | 41.370       | 49.894       |
| Magnesia, MgO, . . . . .                               | 0.988        | 0.732        |
| Sulphuric acid, SO <sub>3</sub> , . . . . .            | 0.000        | 0.000        |
| Potash, K <sub>2</sub> O, . . . . .                    | trace        | 0.000        |
| Soda, Na <sub>2</sub> O . . . . .                      | trace        | trace        |
|                                                        | <hr/> 99.880 | <hr/> 99.986 |

I.—Specimen from gully near surface, 11 south, 27 west, Section 35, northeast quarter of the northeast quarter.

II.—Specimen from block plowed up in field, same section and quarter.

Mr. Jones tells me that a similar rock is found in the northeast quarter of Section 32, in the west half of 27, and in the west half of 26.

*The Upper or Saratoga Chalk near Washington.*—The outcrop of the upper or Saratoga chalk-bed is not continuously exposed

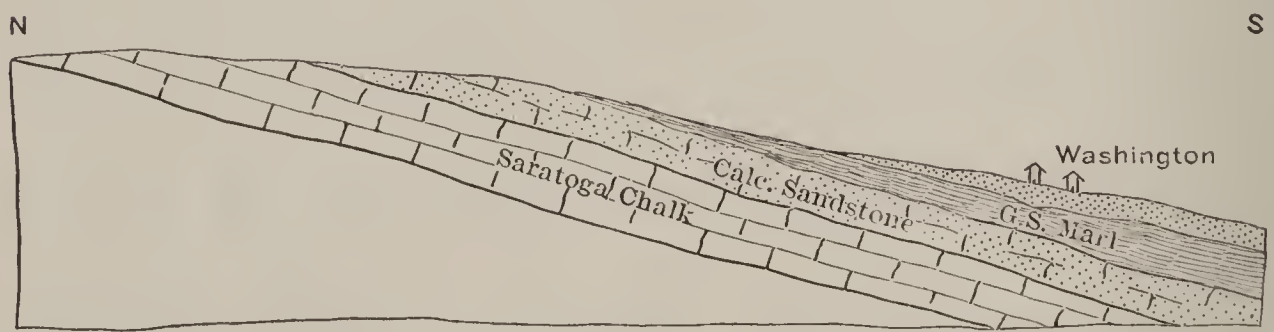


for any great distance; it is for the most part concealed by soil or by an overwash of soil, sands and gravels. The exposures, however, show that it extends from the face of the hill, just east of Saratoga, to Columbus, this latter town standing on or very near its northern margin. From this place it strikes in the direction of Washington, but about a mile west of that town it swings northward and crosses the railway on top of the watershed between Washington and Ozan.

The diagram, Fig. 5, giving the succession of rocks at Saratoga, shows also the succession for Washington and the beds underlying that place. A section at Washington is shown in Fig. 6.

It will be seen that the sections are geologically identical. At Washington, however, the chalk-beds are exposed in the railway-cuts on the water-shed north of and higher than the

FIG. 6.



Section through Washington.

town, while at Saratoga they are at the base of the hill that slopes away to the north, and are lower than the town.

The Washington exposures examined are in the railway-cuts in 11 south, 25 west, about Section 9, about  $2\frac{1}{2}$  miles north and a little west of Washington. Approaching the exposures by the railway-track from the south, the first one shows 7 feet of light-gray chalk at the top of the cut and 4 feet of leaden-gray beneath, without the bottom of the bed being seen.

The light-gray color of the upper chalk seems to be due largely to weathering; there is, at least, a close conformity of the parting line between the two colors and the contour of the exposed surfaces. The freshly-quarried stone stands with angular faces like a hard rock, but it breaks down rapidly under the influence of the weather. Large, fresh blocks taken from the cut and exposed for one year disintegrated and broke down

like so much clay, and the face of the cut within a year came to look more like a bank of clay than a hard rock-face.

Analyses Nos. 6, 8 and 9, Table I., show the composition of average samples taken from the above-mentioned cut.

In the next railway-cut (the one just south of the cut-off made in shortening the railway-track) the rock is less even in texture and has hard spots caused by fossil Cephalopods and Lamellibranchs. A thickness of 10 feet is exposed in this cut. The rock is bluish-gray towards the bottom of the exposure and of a lighter gray at the top. It all disintegrates upon exposure, but not so rapidly as does that in the first cut mentioned above.

No. 7, Table I., is an analysis of the fossiliferous chalk in this railway-cut, made by Dr. A. E. Menke.

The exposures on the railway deserve especial attention on account of their being immediately accessible to railway transportation.

From the point where the chalk crosses the railway north of Washington it runs in a nearly straight line to a point about half-way between Marlbrook and Wallaceburg, where it is cut off or concealed by the overlying sandy beds. Between four and five miles northeast of Washington the chalky bed is about 40 feet thick and seems to be of uniform character. It is capped by about 100 feet of bluish, sandy clay, above which is from 50 to 70 feet of a still more sandy bed. Four miles south-southwest of Wallaceburg it is still forty feet thick, but the bed as a whole varies somewhat. The central part of the bed is somewhat more argillaceous and has more fossils, and the upper four feet have less sand. East of Wallaceburg the upper chalk next appears at and about Okolona. This locality I have not examined personally, but Dr. N. F. Drake, who has visited it for me, says that the chalk similar to that at Saratoga and north of Washington is exposed in the old fields half a mile south and southwest of Okolona, where it has been eroded so that the total thickness is not to be seen at that place. From two to three miles south of Okolona the full thickness of the bed—20 to 30 feet—may be seen. Here it caps the higher hills. From 3 to  $3\frac{1}{2}$  miles south of Okolona the bed dips to the south and disappears beneath gray marls. In this vicinity the material seems to vary in character a little more than usual at different horizons, some beds weathering more rapidly than



others. The analyses of samples taken from the beds that break down more rapidly than others upon exposure leave one in doubt about the reason for this peculiarity. In the case of the Saline landing specimens, it was expected that the cause of this disintegration would be readily detected, especially in view of the sharp contrast between the rocks analyzed. In any case this disintegration of the chalk, until otherwise demonstrated, must be looked upon as a valuable peculiarity, as it will render the crushing of the rock less expensive.

A mile west of Dobeyville this chalk outcrops along the Okolona-Dobeyville road just below a sandy bed. It is about 25 feet thick here, and somewhat harder than usual. The lower 20 feet is quite uniform in character. At Dobeyville there is about 100 feet of marl above the chalky bed, the outcrop passing just north of that town. East of Dobeyville it is cut off by the bottoms of the Terre Noire. East of these bottoms it follows a broken course past Mt. Bethel church, east of which it has not been located. About five miles west of Arkadelphia, and just below the Rome-Arkadelphia road, where it crosses Big Deciper creek, there is an exposure of 15 to 20 feet of the Saratoga chalk. Here it is quite sandy, and probably not more than one-fourth of the rock is limestone, even in the most calcareous portion of the bed.

Where the road crosses the Little Deciper the top of this bed is at or near the level of the road, and the outcrop lies north of Mr. Haskins's place.

*Little Deciper Deposits.*—On the south side of Section 23, 7 south, 20 west, where the Arkadelphia-Washington road crosses Little Deciper creek, 4 miles west and a little south of Arkadelphia, the chalky cretaceous beds are exposed on both the east and west sides of the creek. On the west bank these soft beds are about 25 feet thick, with a few fossil bivalves exposed by weathering on the surface. Above the chalky bed is a bed of brown sandy rock about 6 feet thick, and this is overlain by bright red overwash containing water-worn cobbles. These beds dip gently down the stream.

#### TABLE OF ANALYSES OF CHALKS.

I give below all the quantitative analyses that I have had made of the Arkansas chalks, and also those made by Prof. N.

W. Lord, of the Ohio State University, by Dr. Joseph Albrecht, of the United States Mint, New Orleans, and by Dr. Henry Froehling, of Richmond, Va., for the White Cliffs Portland Cement and Chalk Company, and contained in the company's prospectus, published at New Orleans in 1894. I do not know from what part of the beds the samples were taken. So far as I know, these are the only analyses that have thus far been made of them.

TABLE I.—*Analyses of Arkansas Chalks,*  
*Giving Silica, Ferric Oxide, Alumina, Magnesia, Lime, Alkalies, Carbon Dioxide,*  
*and Water; also the (calculated) Carbonates of Lime and Magnesia.*

| No.     | SiO <sub>2</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | MgO.   | CaO.  | Alka-<br>lies. | CO <sub>2</sub> . | Water<br>at 110°-<br>115° C. | CaCO <sub>3</sub> . | MgCO <sub>3</sub> . |
|---------|--------------------|----------------------------------|----------------------------------|--------|-------|----------------|-------------------|------------------------------|---------------------|---------------------|
| 1.....  | 9.77               | 1.25                             | *                                | Trace. | 49.55 | .....          | 38.93             | .....                        | 88.48               | .....               |
| 2.....  | 12.69              | .....                            | .....                            | "      | 46.87 | .....          | 36.83             | 1.22                         | 83.70               | .....               |
| 3.....  | 12.69              | .....                            | .....                            | "      | 45.38 | .....          | 35.66             | 2.04                         | 81.04               | .....               |
| 4.....  | 10.46              | .....                            | .....                            | "      | 45.70 | .....          | 38.28             | 1.57                         | 86.98               | .....               |
| 5.....  | 8.91               | .....                            | .....                            | "      | 49.82 | .....          | 39.15             | 1.26                         | 88.97               | .....               |
| 6.....  | 24.49              | 1.68                             | 6.27                             | 0.92   | 34.63 | 0.86           | 29.95             | .....                        | 61.84               | 1.93                |
| 7.....  | 16.12              | 1.62                             | 5.64                             | 0.42   | 42.17 | 0.41           | 34.52†            | .....                        | 75.30               | 0.88                |
| 8.....  | 32.80              | 1.45                             | 6.32                             | 1.91   | 25.95 | 1.66           | 26.97†            | .....                        | 46.35               | 4.01                |
| 9.....  | 32.39              | 1.99                             | 6.63                             | 1.45   | 25.61 | 1.50           | 26.10†            | .....                        | 45.73               | 3.02                |
| 10..... | 15.89              | 1.40                             | 5.46                             | 0.60   | 42.49 | 0.35           | 34.61†            | .....                        | 75.87               | 1.26                |
| 11..... | 5.69               | 1.48                             | 4.22                             | 1.20   | 48.72 | 0.26           | 38.64†            | .....                        | 87.01               | 0.85                |
| 12..... | 12.01              | 1.06                             | 5.29                             | 1.21   | 44.25 | 0.32           | 35.99†            | .....                        | 79.01               | 2.50                |
| 13..... | 10.35              | 1.97                             | 3.02                             | .....  | 46.61 | .....          | 36.63             | .....                        | 83.24               | .....               |
| 14..... | 3.49               | 1.41                             | *                                | 0.65   | 52.74 | .....          | 42.16             | .....                        | 94.18               | 1.37                |
| 15..... | 4.42               | 1.03                             | 2.21                             | .....  | 53.36 | .....          | 41.93             | 3.81                         | 95.29               | .....               |
| 16..... | 5.53               | 1.34                             | 1.44                             | .....  | 51.71 | .....          | 40.63             | .....                        | 92.34               | .....               |
| 17..... | 7.76               | 1.26                             | 2.58                             | .....  | 49.45 | .....          | 38.85             | 1.15                         | 88.30               | .....               |
| 18..... | 3.34               | 0.89                             | 1.80                             | .....  | 52.78 | .....          | 41.47             | .....                        | 94.24               | .....               |
| 19..... | 5.04               | 0.58                             | 3.26                             | .....  | 49.92 | .....          | 39.23             | .....                        | 89.15               | .....               |
| 20..... | 6.09               | 1.20                             | 3.52                             | .....  | 49.24 | .....          | 38.69             | .....                        | 37.93               | .....               |
| 21..... | 5.74               | 0.48                             | 1.02                             | .....  | 30.91 | .....          | 40.00             | .....                        | 90.91               | .....               |
| 22..... | 16.62              | 1.51                             | 5.34                             | 0.99   | 41.37 | .....          | 34.05†            | .....                        | 73.87               | .....               |
| 23..... | 5.00               | 1.22                             | 2.79                             | 0.73   | 49.89 | .....          | 40.35†            | .....                        | 89.09               | .....               |

1. Rocky Comfort. 2 and 3. Gully in south part of Rocky Comfort; 2. cream-colored; 3. bluish-gray. 4. Hawkins's well, east of Rocky Comfort. 5. Rocky Comfort, weathered. 6. Upper (7 feet) bed in first railroad-cut, 2½ miles north of Washington. 7. Analysis by Menke of fossiliferous chalk from second railroad-cut north of Washington. 8 and 9. Lower (4 feet) bed from same cut; No. 8 from north end. 10, 11 and 12. Saline Landing; No. 12 a bed exposed on creek which slacks more readily than the others. 13. White Cliffs, base of Kingsworthy's ledge. 14. White Cliffs, sample taken by Prof. R. T. Hill on Col. Coulter's farm, 11 S., 29 W., Sec. 26 (?), exact locality not known. 15. Do., from roadside, N.E. qr. of N.E. qr., Sec. 35, 11 S., 29 W. 16. White Cliffs, light-colored rock below the upper chalk-beds. 17. Do., soft bluish chalk from beneath the chalk-

\* Alumina included with iron oxide.  
† Loss by ignition, comprising carbonic acid and water.



beds. 18. Do., hard bed immediately beneath the chalk-beds. 19, 20 and 21. White Cliffs, precise locality not stated; No. 19 by N. W. Lord; 20 by Joseph Albrecht; 21 by H. Froehling. 22 and 23. Farm of T. L. Jones, 11 S., 27 W. Sec. 35; No. 22 from a gully, near the surface; No. 23 from a block plowed up in the field.

#### AVAILABLE CLAYS.

Clays, to be available for the manufacture of Portland cement, must, besides having the right composition, be sufficiently abundant, uniform in character and convenient to transportation to make them cheap and trustworthy. In no case with which I am acquainted are the surface-clays found in the immediate vicinity of the chalk-deposits to be depended upon. Such clays are, as a rule, too sandy and too thin, and, above all, they are not of uniform composition. Reference is here made especially to the leached sandy clays or "slashes" overlapping the chalk-beds to the north and east of Rocky Comfort, and the clays of the bottom-lands south and west of White Cliffs, and those south, north and west of the chalk-exposures at Saline landing. Fortunately, the Tertiary rocks which overlap the Cretaceous ones to the south and east contain an abundance of excellent clays available for the manufacture of cement. Some of these clay-beds are already being utilized for the manufacture of pottery at Benton and Malvern (Perla switch). At these two points the beds are on the railway. There are many other deposits on and near the railway that are as yet unused, and, indeed, generally unknown. Such occur about Arkadelphia, Malvern, between Malvern and Benton, between Benton and Bryant, at Olsen's switch and at Mabelvale. At Little Rock also there are extensive beds of both clays and clay-shales, while scores of beds of clay-shales may be found along the line of the Little Rock and Fort Smith road to Fort Smith and beyond.

The Tertiary clays at Benton, Bryant, Olsen's switch, Mabelvale and Little Rock are all horizontal or nearly horizontal beds dipping gently toward the southeast. They can be had in many places by stripping off a few feet of post-Tertiary gravel and soil; but in places the covering is too thick to be removed, and the clays can be had only by a system of drifts. In some instances the clay-beds are so nearly uniform in character as to give rise to the idea that they have the same composition throughout. This, however, is true only in a limited

sense: the clays do not seem to vary within the small areas thus far worked, but it is highly probable that they will be found to change to sands when a wide area is taken into consideration.

This is not a serious objection to the deposits, however, as there is no possibility of the supply being exhausted.

*Cost of Clays.*—The lands through the region of Tertiary clays can probably be had for \$10 an acre, and for even less than that, as they are generally of small value for agricultural purposes. In some places short switches can be built into the clay-banks, and the clays can be shoveled directly from open cuts into cars. In case it should be necessary to haul to the railway, teams can be had for \$2 a day, driver included, and labor at from 75 cents to \$1 a day, and outside of the farming season for even less. The employees board themselves and their teams. Hauling must be done in Arkansas mostly in the summer and fall, as the winter and spring rains usually make the common country-roads impassable.

*Location of Clays.*—The following information regarding the local conditions of occurrence may be useful to those seeking information about the Arkansas clays. Only a few of the many known localities are here mentioned. On account of the geographical relations to the chalk-beds, only those places convenient to railway transportation along the St. Louis, Iron Mountain and Southern Railway southwest of Little Rock are spoken of in this paper. Should a factory, on account of fuel or for other reasons, be located west of Little Rock, clays derived from the Carboniferous clay-shales would have to be used. Of these there is no lack between Little Rock and Fort Smith.

*Clays at Little Rock.*—There are two general classes of clays at Little Rock available for cement-manufacture: (1) the *Tertiary clays* that occur in horizontal beds in the southern and southwestern part of the city; and (2) the *Carboniferous clay-shales* exposed in the railway-cuts along the south bank of the Arkansas river, in the cuts west of the town, and in others west of Argenta.

There are other clays about Little Rock and Argenta, such as the chocolate-colored clays along the margins of the river-bottoms, and the pinkish clays forming the high river-terraces



and used for bricks on the north side of the river; but these latter two kinds of clays are not available for cement-manufacture, partly because they are too sandy, but also because they are not homogeneous. An analysis of the pink clay of Argenta shows it to contain more than 83 per cent. of silica.

The Tertiary clays were laid down, like the other Tertiary beds of Arkansas, as sediments in water. These strata were originally, and are still, very nearly horizontal. After the old sea-bottom was elevated, however, the ordinary erosion cut down and washed away these soft sediments rapidly, so that now there remains on the hills but a small part of the original beds, and these have been still further obscured by gravels, clays and soils that cover most of the region. The original bedding of these clays is to be seen only in a few deep gullies along the west-sloping hills in the western part of the city, and in the wells that penetrate them. They are of an olive-green to gray color, and upon exposure break up in small cuboidal fragments, or, when thoroughly wet, pack together closely. They are cut in several gullies in the southwestern part of the city, and are penetrated by many of the wells.

The Carboniferous clay-shales are too well exposed in the railway-cut near the upper bridge, and where the electric power-house stands, to require description. Similar shales may be found here and there over a large part of Pulaski county, within the Carboniferous area.

The objection to these shales is that they require grinding before they can be used in cement-making, and the grinding, of course, makes them more expensive.

*Composition of the Clays.*—The following analyses show the composition of the common run of the pottery clays and fullers' earths of Arkansas. These analyses are of representative samples, and a reasonable assurance may be given that the clays as found in place are as nearly homogeneous as clays ever are. Most of them contain some sand, usually quite fine. In those cases in which the percentage of sand is given the analyses are of the washed clay. This table might be greatly extended, as I have analyses of a large number of the clays of Arkansas. These, however, will give a correct idea of the general nature of the clays.

TABLE II.—*Analyses of Typical Carboniferous Clay-Shales from Arkansas,*

*Giving Silica, Alumina, Ferric Oxide, Lime, Magnesia, Soda, Potash, and Water.*

| No.    | SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO.   | MgO.   | Na <sub>2</sub> O. | K <sub>2</sub> O. | Water. | Total. | Sand in Air-Dried Clay. |
|--------|--------------------|----------------------------------|----------------------------------|--------|--------|--------------------|-------------------|--------|--------|-------------------------|
| 1..... | 53.30              | 23.29                            | 9.52                             | 0.36   | 1.49   | 2.76               | 1.36              | 5.16   | 100.48 | .....                   |
| 2..... | 62.36              | 25.52                            | 2.16                             | 0.51   | 0.29   | 0.66               | 1.90              | 5.32   | 98.72  | .....                   |
| 3..... | 58.43              | 22.50                            | 8.36                             | 0.32   | 1.14   | 1.03               | 2.18              | 6.87   | .....  | .....                   |
| 4..... | 65.12              | 19.05                            | 7.66                             | 0.34   | 0.31   | 0.85               | 1.23              | 6.12   | .....  | 21.88                   |
| 5..... | 57.12              | 24.32                            | 8.21                             | 0.72   | 1.74   | 0.53               | 2.07              | 7.58   | .....  | .....                   |
| 6..... | 55.36              | 26.96                            | 5.12                             | 0.30   | 1.16   | 1.03               | 2.69              | 7.90   | 100.52 | .....                   |
| 7..... | 51.30              | 24.69                            | 10.57                            | 0.32   | 0.63   | 0.72               | 2.18              | 9.11   | .....  | .....                   |
| 8..... | 69.34              | 22.56                            | 1.41                             | Trace. | Trace. | 2.31               | 0.04              | 5.12   | .....  | .....                   |

1. Clay-shale from railroad-cut at south end of upper bridge, Little Rock. 2. Decayed shale from Iron Mountain Railroad-cut, at crossing of Mt. Ida road, Little Rock. 3. Clay-shale from Nigger Hill, Fort Smith. 4. From Harding & Boucher's quarry, Fort Smith. 5. Clay-shale from Round Mountain, White county, Sec. 6, 5 N., 10 W. 6. From Clarksville, east of college. 7. From S.E. qr. of S.W. qr., Sec. 31, 10 N., 23 W. 8. From N.W. qr., Sec. 23, 1 N., 13 W.

TABLE III.—*Analyses of Typical Tertiary Clays from Arkansas.*

| No.     | SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO.              | MgO.      | Na <sub>2</sub> O. | K <sub>2</sub> O. | Water <sup>r</sup> . | Titanic Acid. |
|---------|--------------------|----------------------------------|----------------------------------|-------------------|-----------|--------------------|-------------------|----------------------|---------------|
| 1.....  | 63.07              | 23.92                            | 1.94                             | 0.23              | Trace.    | 1.08               | 1.15              | 7.07                 | .....         |
| 2.....  | 72.44              | 18.97                            | 1.59                             | 0.18              | Trace.    | 0.91               | 1.35              | 5.39                 | .....         |
| 3.....  | 69.95              | 22.34                            | 1.44                             | Trace.            | 0.08      | 1.18               | 1.28              | 5.98                 | .....         |
| 4.....  | 71.09              | 19.86                            | 1.81                             | 0.11              | .....     | 0.81               | 1.45              | 5.67                 | .....         |
| 5.....  | 65.27              | 18.75                            | 7.34                             | 0.81              | 1.26      | 0.81               | 1.10              | 6.88                 | .....         |
| 6.....  | 64.38              | 17.29                            | 8.25                             | 1.11              | 0.80      | 0.42               | 1.41              | 6.95                 | .....         |
| 7.....  | 63.19              | 18.76                            | 7.05                             | 0.78              | 1.68      | 1.50               | 0.21              | 7.57                 | .....         |
| 8.....  | 64.49              | 23.86                            | 2.11                             | 0.31              | Trace.    | 1.82               | 0.11              | 8.11                 | .....         |
| 9.....  | 67.90              | 22.07                            | 1.33                             | 0.05              | 0.59      | 0.38               | 1.15              | 6.86                 | .....         |
| 10..... | 48.34              | 34.58                            | 1.65                             | 0.81              | Trace.    | 1.26               | 0.44              | 12.94                | 1.56.         |
| 11..... | 62.34              | 20.63                            | 3.34                             | 0.17              | 0.67      | 0.33               | 0.73              | 9.34                 | 1.49.         |
| 12..... | 68.03              | 17.19                            | 3.00                             | 0.81              | 1.00      | 0.54               | 1.00              | 6.31                 | .....         |
| 13..... | 63.29              | 18.19                            | 6.45                             | 0.31              | 2.44      | Trace.             | 0.56              | .....                | .....         |
| 14..... | 76.33              | 16.04                            | 1.24                             | By dif. 0.99..... |           |                    |                   | 5.40                 | ..            |
| 15..... | 75.99              | 16.12                            | 1.35                             | By dif. 1.45..... |           |                    |                   | .....                | .....         |
| 16..... | 73.24              | 19.61                            | 1.04                             | By dif. 0.78..... |           |                    |                   | .....                | .....         |
| 17..... | 45.28              | 37.39                            | 1.71                             | 1.83              | 0.29..... |                    |                   |                      | 13.49         |

1. Benton, Hicks's bed, 2 S., 15 W., Sec. 12. 2. Benton, Rodenbaugh, 2 S., 15 W., Sec. 12. 3. Benton, Herrick & Davis's bank. 4. Benton, Henderson's pit, upper bed. 5. Mabelvale, A. W. Norris's well. 6. Olsen's switch, "fullers' clay." 7. "Fullers' earth," Alexander, 1 S., 13 W., Sec. 8, S.W. of S.E. 8. Benton, Woolsey's clay. 9. Ridgwood, 1 N., 12 W., Sec. 25, S.W. qr. of N.E. qr. 10. Benton, Howe's pottery. 11. Clay from 8 S., 15 W., Sec. 4. 12. Clay from 8 S., 15 W., Sec. 5. 13. Clay from 2 S., 13 W., Sec. 13, S. half. 14. John Foley's,



13 S, 24 W., Sec. 18, N.E. of S.E. 15. Climax pottery, 15 S., 28 W., Sec. 5, W. half, S.E. qr. 16. Atchison's, 4 S., 17 W., Sec. 24, N.E. qr. of N.E. qr. 17. Kaolin, 1 N., 12 W., Sec. 36, Tarpley's.

According to Professor Jameson\*, clays for Portland cement should not contain less than about 60 per cent. of silica in combination.

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\* *Portland Cement*, by Charles D. Jameson, Iowa City, 1895, p. 17.











